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ACOUSTIC SCALING:
THE DESIGN OF A LARGE MUSIC STUDIO FOR MANCHESTER
Final Report

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Summary

This report gives the results of further modifications to the design of the large music studio for Manchester[1] *and assesses their performances subjectively and objectively. Final recommendations for the design are given and these should not only result in a better design than the original, but in a lower cost.*

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1. Introduction

An interim report[1] has discussed the application of acoustic scaling to the design of a large music studio proposed for Manchester. The effect on the sound quality of varying the height of the studio was examined and various possible shapes of the reverberation time/frequency curves were assessed, for a midband reverberation time of 1·9 secs. As a result of hearing the sound quality from the model studio under these various conditions, it was felt desirable by the potential users to investigate the effects on sound quality of longer reverberation times, and this final report gives details both of this later programme of work and of the subsequent recommendations for the design of the studio.

2. Experimental details

The general size, layout and appearance of the studio were fully described in the interim report[1] and will not be repeated here. The same types of model modular absorber were used for the present test as for the previous ones, but were varied in number to obtain the desired reverberation times; the 100% Melinex condition was exclusively used. As was shown in Fig. 7 of the interim report the absorption at high frequencies in a full-size studio of this size is largely due to the air and will not therefore be appreciably affected by the number of modular absorbers present. In the subsequent description, the reverberation times quoted strictly apply, therefore, to the bass and midband frequency ranges only.

The optimum design figure for the reverberation time of a full-size studio of this volume, i.e. 8500 m^3 (300,000 ft^3) would normally be regarded[2] as 1·8 secs., that is roughly the figure already tested; but the operational departments after hearing this condition by means of the model requested an examination of the effects on sound quality of increasing this time to 2¼, 2½ and 2¾ secs., with the object of going beyond the optimum values. At the same time the effect of the two heights previously examined for the studio could be checked with the new range of reverberation times.

The reverberation time/frequency curves actually obtained for the six conditions mentioned, are shown in Figs. 1 and 2. It will be seen that, as expected, there is a progressive relative falling off in high frequency reverberation time as the midband figure is increased, in spite of the use of the Melinex film on the model absorber modules, as described in the interim report.

3. Subjective assessments

Subjective assessments of the sound quality from the recordings were made in a manner previously described,[3] using an ABAB comparison of the test recording B with an arbitrary standard A. For the present test the standard chosen was the recording obtained with 2¼ secs. reverberation time and an equivalent height of 12 m (40 ft); this represents a condition between the two extremes to be assessed. It was found previously that six conditions were the most that subjects could be asked to compare in one session without undue fatigue, and consequent loss of discrimination; even with this number of conditions a break of 15 mins in the middle of the test was found desirable. This meant that all conditions recorded were not assessed, especially as it was again thought desirable to include a check of the subjects' acuity. The test conditions chosen were:— (a) 1·9 secs. at 12 m height, (b) 2¼ secs. at 12 m height, (c) 2¼ secs. at 14 m height, (d) 2½ secs. at 14 m height, (e) 2½ secs. at 12 m height, and (f) 2¾ secs. at 14 m height.

The microphone placing was maintained constant for all recordings and it follows, therefore, that the recordings with the high reverberation time have a perspective different from those with the shorter reverberation times. The questionnaire asked for an assessment of the sound quality of the test recording B relative to that of the standard A, but in some cases observers stated that in fact they had gone further than this and assessed the potential sound quality which they predicted would have been obtained, had they been permitted to re-position the microphones to give the optimum sound balance.

4. Results

The results are given in Table 1 both for all observers and for the fifteen who passed the acuity test, i.e. they gave scores of zero or near to zero in comparison No. 3 and gave scores exceeding + or − 0·5 on at least some of the other comparisons. It should be noted that the total range of assessment is −5 through 0 to +5: a positive sign signifies 'dislike', a negative sign signifies 'like'.

These results are plotted in Figs. 3 and 4 where the trends are more easily seen. The general consensus of opinion is for an optimum reverberation time in the 2¼ to 2½ secs. region with the consistent observers tending to prefer the higher value. Theoretically the individual standard errors do not allow for such discrimination but the consistent trends of the results lend further weight to this argument.

TABLE 1

Summary of Overall Assessments for 6 Comparisons

Test	1	2	3	4	5	6
Mid-frequency reverberation time (secs.)	2·75	1·9	2·25	2·5	2·25	2·5
Roof ht. metres (ft)	14(45)	12(40)	12(40)	14(45)	14(45)	12(40)
All observers (n = 27)						
Mean grading	0·122	0·467	−0·422	−0·200	−0·022	−0·193
Standard error	0·212	0·216	0·178	0·225	0·154	0·227
All consistent observers (n = 15)						
Mean grading	0·233	0·713	−0·040	−0·273	0·060	0·007
Standard error	0·248	0·254	0·029	0·290	0·195	0·267

It is interesting to note that contrary to previously established views,[2] the preference for 2¾ secs. reverberation time is in fact very little less than that for the optimum, and is greater than that for the conventional value of 1·9 secs.

This result confirms opinions held by some operational staff that there is now a growing tendency to prefer studios that are more reverberant than previously constructed. It should, however, be appreciated that it does not necessarily hold that this tendency applies to concert halls where the ratio of direct to reverberant sound is not under the control of a member of the audience. As before, the variation in preference for a particular height is too small to be significant statistically.

5. Discussion

It will be noted that the sound quality obtained for the optimum condition in this last set of experiments was definitely preferred to that for the 1·9 secs. condition. In view of the fact that this latter condition had already been described by the observers as satisfactory[1] there should be little doubt about the acoustic quality of the latest recordings. These results have been communicated to the acoustic consultants finally responsible for the studio design and they have recommended that a studio height of 14 m (45 ft) be used together with a reverberation time of 2¼ secs. midband.

6. Conclusions

As a direct result of the use of acoustic scaling, the recommended acoustic design of the studio is very different from that originally planned. The potential users consider the final design to be appreciably better than the original and it is noteworthy that the cost of the acoustic treatment should now be much less than it would have been.

The use of acoustic scaling in this connection has been invaluable in demonstrating previously unknown variations of acoustic absorption, due to surroundings, which would otherwise have resulted in costly modifications after completion. In addition the ability to listen and assess subjectively the potential sound quality of various modifications has led to a final design which, potentially, is not only superior to the original design, but also appreciably cheaper.

7. References

1. HARWOOD, H.D. et al. Acoustic scaling: the design of a large music studio for Manchester. Interim Report. BBC Research Department Report No. 1975/11.

2. BURD, A.N. et al. Data for the acoustic design of studios. BBC Engineering Division Monograph No. 64, November 1966.

3. HARWOOD, H.D. et al. Acoustic scaling: an examination of possible modifications to Maida Vale Studio No. 1. BBC Research Department Report No. 1974/27.

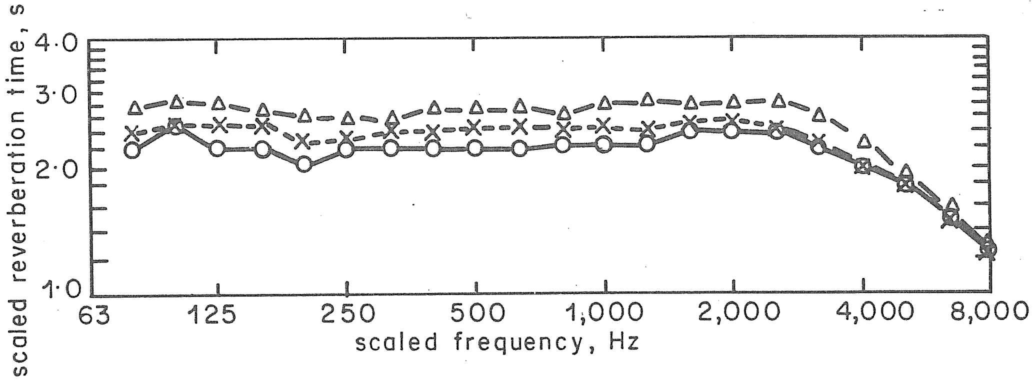

Fig. 1 - Reverberation time/frequency curves for proposed Manchester music studio. Height 12 m

○——○ 2¼ secs
×- - -× 2½ secs
△——△ 2¾ secs

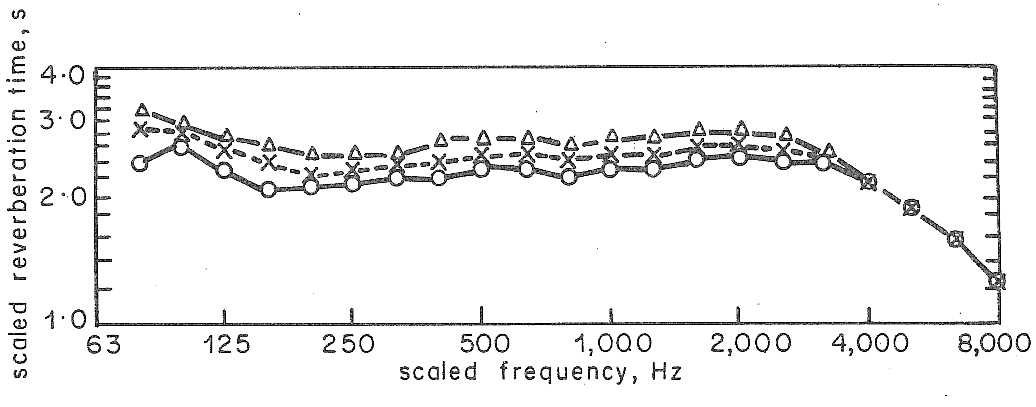

Fig. 2 - Reverberation time/frequency curves for proposed Manchester music studio. Height 14 m.

○——○ 2¼ secs
×- - -× 2½ secs
△——△ 2¾ secs

See overleaf for Figs. 3 and 4.

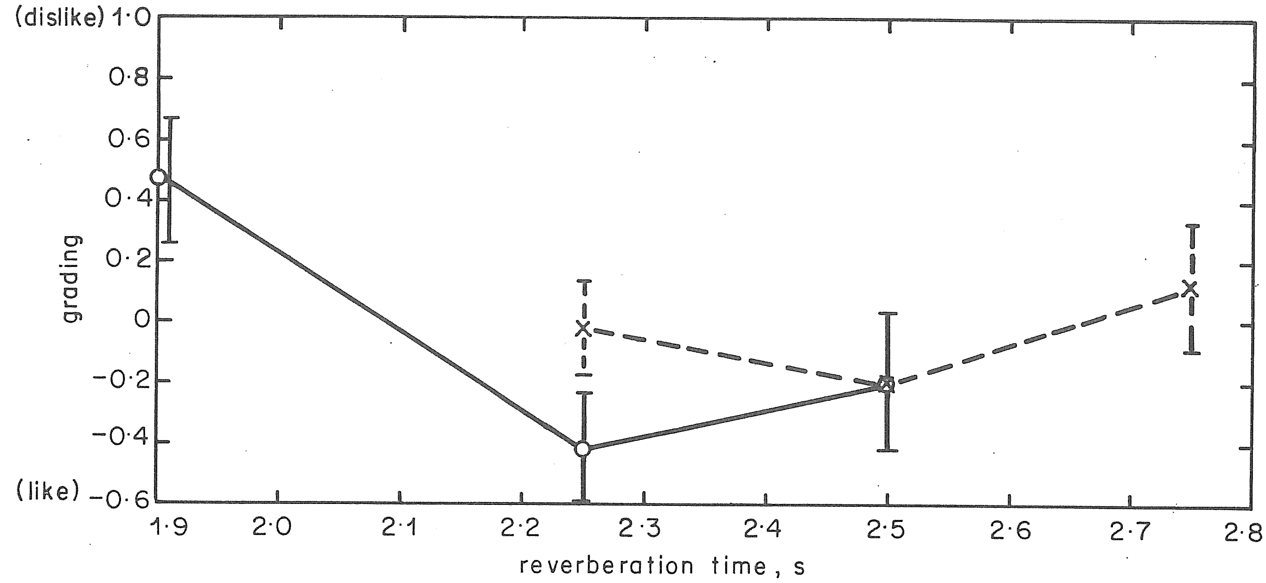

Fig. 3 - Subjective overall ratings for proposed Manchester music studio. All observers

○ 12 m
× 14 m
Standard error 12 m
Standard error 14 m

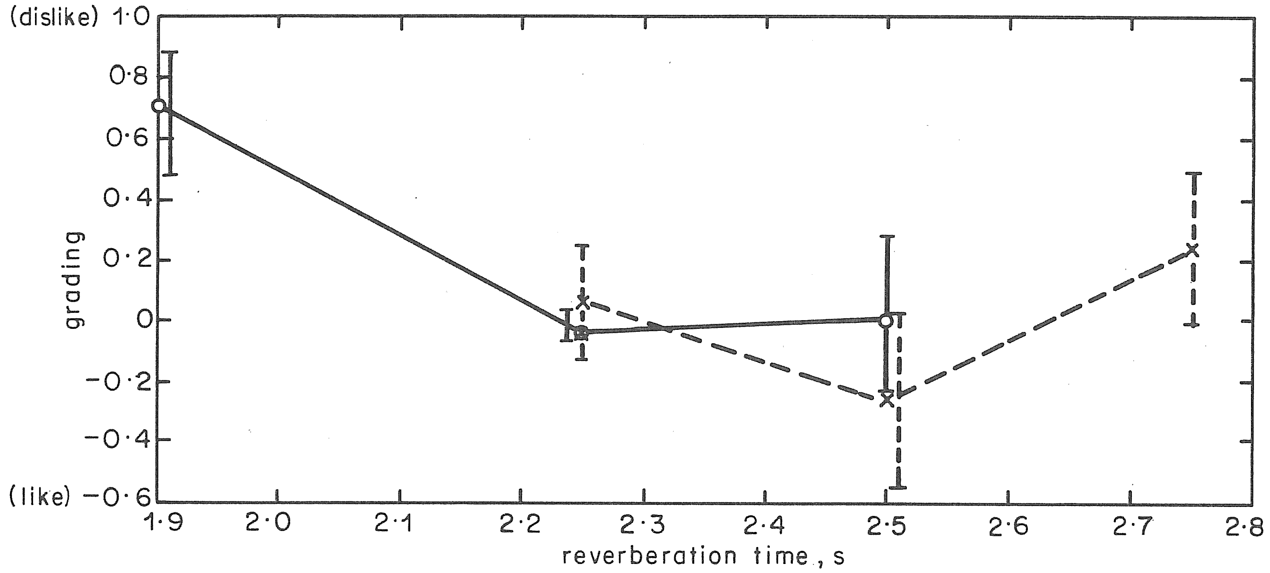

Fig. 4 - Subjective overall ratings for proposed Manchester music studio. 15 consistent observers only

○ 12 m
× 14 m
Standard error 12 m
Standard error 14 m

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